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CAPITAL CONSTRUCTION IN THE METAL INDUSTRY

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TECHNICAL SPECIFICATIONS FOR BRICKLAYING AND CONSTRUCTION OF THE HUNG-CH'I COKE OVEN (DRAFT)

[This is a full translation of an article submitted by the Capital Construction Department, Ministry of Metallurgical Industry, appearing in Yeh-chin Chien-she (Metallurgical Construction), No 12, Peiping, 21 April 1959, pages 9-11.]

No 1. These technical specifications are suitable for the bricklaying and construction of the Red Flag (Hung-ch'i) No 3 and Red Flag No 2 coke ovens.

No 2. The bricklaying of the coke ovens should be carried out according to design.

No 3. The bricklaying of the oven structure may only be carried out after its center line and foundation elevation have been examined and found to meet specifications.

No 4. When the construction of the oven structure is carried out during the winter or rainy season, a work shack should be set up. The work shack should be heated during winter.

No 5. Refractory materials meeting requirements should be used in the bricklaying and construction of coke ovens. Refractory brick blanks (p'i) should not be used in the bricklaying and construction of coke ovens.

No 6. The mixed use of clay bricks and silica bricks is forbidden.

No 7. The sorption of any moisture by refractory bricks should be prevented. Every effort should be made to store special shapes of clay brick used for the vertical flue section in the warehouse; otherwise, measures to prevent them from sorbing any moisture should be adopted.

Refractory clay bricks and silica bricks must be stored in the warehouse.

No 8. During bricklaying, a wooden hammer is to be used in putting the bricks in place. The use of a metal hammer is forbidden.

The processing of bricks [cutting or chipping] after the brick structure has been laid is not allowed.

No 9. The method of adhering and squeezing the mortar should be used in bricklaying. The joints between bricks must be completely filled and there should be no empty gaps.

No 10. Before the actual laying of the coke oven, representative brick layers of sections of complicated structures should be pre-laid or dry-arranged.

If necessary, the arrangement of the layers of bricks of the slanting flue duct area may be altered.

No 11. Special shapes for the vertical flue should be selected on the basis of the longitudinal dimension of the carbonization chamber before the start of construction. Bricks with different tolerances [bricks of slightly larger or smaller sizes] should be placed in separate piles and, during construction, larger and smaller bricks should be used together to guarantee an evenness of the brick joints.

To guarantee that the slanting flue duct will be in its correct position, standard bricks for the slanting flue duct section should also be examined or spot-checked.

No 12. For the laying of each section, a guide line should be used.

No 13. The spacing of the brick joints of the refractory structure is to be examined with a thickness gauge. The width of the thickness gauge is 15 millimeters and its thickness is equal to the spacing of the brick joints to be examined as specified under these specifications.

No 14. The specifications of the fire clay used in bricklaying is given in Table 1.

Table 1. Fire Clay Specifications

Item No	Type of Brick	Fire Clay Used	Specifications and Requirements
1	Silica brick	Low temperature silica fire clay	Operating temperature between 1,000 - 1,350°C.
2	Clay brick	Fire clay	Second class medium grain.
3	Red brick	1) Fire clay for oven roof	Second class medium grain.
		2) Surface of oven roof:	
		Fire clay 50%	Second class medium grain.
		Cement 30%	No 200 ordinary silicate cement or slag silicate cement.
		River sand	Grain size smaller than 3 millimeters.
		3) For other sections, use 2 parts fire clay and 1 part cement.	Second class medium grain fire clay and No 200 ordinary silicate cement or slag silicate cement.

No 15. Use a mortar of semithick consistency in the laying of bricks. The mortar must be prepared with clean water.

Note: A mortar of semithick consistency is one that is prepared by adding 500 liters of water to every cubic meter of dry material.

No 16. The brick joint spacing of the refractory structure is 3 - 6 millimeters.

The brick joint spacing of the red brick structure is 5 - 9 millimeters.

No 17. The difference between the dimensions of the brick structure and the designed dimensions should not exceed the tolerances specified in Table 2.

Table 2. Permissible Error in Bricklaying

Item No	Type of Error	Value of Error (tolerance)(mm)
1	Elevation error:	
	1) Foundation surface	+0
	2) Surface of bottom support of red bricks	-30 ±10
	3) Surface of slanting flue duct brick passing bottom brick layer of oven roof	± 5
	4) Surface of top layer of slanting flue duct	± 5
	5) Surface of topmost layer of vertical flue	± 7
	6) Surface of oven roof	±20

Table continued--

	7) Elevation difference between bottom of vertical flue and top of carbonization chamber adjacent to it	5
2	Error of verticality:	
	1) Wall of carbonization chamber	5
	2) Combustion chamber and slanting flue duct "oven head"	6
3	Error in linear dimension:	
	1) Center line of combustion chamber	± 5
	2) Length of carbonization chamber	±12
	3) Width of carbonization chamber	± 5
	4) Cross-sectional dimension of air and waste gas duct at bottom of vertical flue	± 4
	5) Diameter of coal gas opening at bottom of vertical flue	± 3
	6) Center line to center line distance of coal gas opening and air hole along longitudinal direction of carbonization chamber	± 4
4	Local disalignment of brick structure (to be examined in all directions with a 1.5 meter wooden guide ruler and the spacing between the guide ruler and the brick structure is the measure of crookedness disalignment:	
	1) Lower bottom of first layer of vertical flue	5

Table continued--

	2) Wall of carbonization chamber	5
	3) Combustion chamber oven head	6
5	Width of expansion joint:	± 2

Note: In the survey of elevations, the dimensions of sections may be accurately determined with a line rod (hsien-kan) from the standard base point.

No 18. Before laying the botton [or base], the center lines of the various combustion chambers should be accurately determined on the side of the foundation on the basis of the center lines of the two carbonization chambers at the ends of the oven (a lengthwise "heng-lieh piao-pan" [some kind of measuring or dividing device] may be used).

The boundary lines on the machine side, the oven side and at the head of the furnace should also be determined in advance.

No 19. Rods with marked dimensions should also be placed on the sides of the machine and the oven, so that the exact elevations of the various layers of bricks could be controlled.

No 20. The center lines, boundary lines and the elevations of the important layers of bricks should be marked with ink lines. The accumulated error of the marked lines should not exceed two millimeters.

No 21. Before laying the base, local spots on the foundation, which are not even, should be cleaned and then evened out with mortar in which the cement to sand ratio is 1:3.

No 22. The arches (spans of less than 500 millimeters) of air and waste gas ducts at the heat storage chamber section may be laid "t'ui-t'ai" [literally, could mean after the construction framework has been removed].

No 23. Wedge shaped bricks should be used in laying the arches of the heat storage chamber and the brick joint spacing should be two millimeters.

No 24. In the trangular area between the two arches of the heat storage chamber, broken pieces of bricks with thick mortar may be used to fill sections of less than half a brick wide. However, compactness should be guaranteed.

No 25. In laying the levelling layer of the heat storage chamber arches, attention should be paid to the layers of bricks in the center and on the two sides. For this reason, lengthwise and crosswise lines should be used.

No 26. Braces inside the oven, used to stabilize the oven colums, should be accurately placed. Only after their elevations, center lines, and their extended sections have been checked and found to meet specifications, and after they have been held firmly with a thick mortar is the layer of bricks above allowed to be laid.

No 27. The various ducts on the first layer of the slanting flue duct should be laid only after their dimensions have been marked according to the design.

No 28. The center dividing walls of the coal gas and air ducts at the connecting flue between the oven halves (pan-lu), at the coke oven, and at the slanting flue duct areas should be very carefully laid. The bricks of the dividing wall should be staggered with those of the oven wall and the expansion joint of the dividing wall should be placed inside the wall.

No 29. Before laying the first layer of the vertical coal gas duct, the bricks should be dry-arranged, their joints examined and the position checked with a large ruler to make sure that design requirements are met, and then lines for the upper and lower layers of bricks should be marked before actual laying begins.

No 30. In laying the slanting flue duct, the brick joints should be solidly filled to prevent the intermixing of coal gas, air and waste gases.

No 31. The dimensions of the first layer of air and waste gas slanting flue duct should be marked on the lower brick structure before its actual laying begins.

No 32. The verticality of the coal gas duct should be checked with a templet smaller than the diameter of the duct.

The error in verticality of the coal gas, air and waste gas ducts should not be larger than four millimeters.

No 33. Expansion joints and sliding joints should be left according to the design. No mortar is placed beneath the sliding joint paper.

No 34. Before the various ducts are covered, loose mortar and other debris inside the ducts should be cleaned out.

No 35. The first layer of bricks of the vertical flue may be laid only after the accuracy of the center line of the combustion chamber and the marked lines for the width of the carbonization chamber have been checked.

The coal gas, air and waste gas openings of the topmost brick layer of the slanting flue duct should also be checked.

No 36. Before the laying of the first layer of the vertical flue, the bricks should be dry-arranged, their joints examined and the position of the vertical flue checked with a large ruler, and then lines for the upper lower layers of bricks should be marked before actual laying begins.

The layer of bricks of the vertical flue should not cover up the coal gas, air and waste gas openings.

No 37. The verticality on the carbonization chamber side of the first layer of bricks of the vertical flue should be strictly maintained.

No 38. The laying of the vertical flue should be made with "mortar on both sides" (mortar should be placed on both touching brick surfaces before laying). The brick

joints should be solidly filled and these joints on both sides of the vertical flue should be smoothly grooved as the laying progresses.

No 39. The bottom lining bricks of the carbonization chamber should be laid after four or five layers of bricks of the vertical flue have been laid.

The bricks should be selected in advance according to their width, and bricks of larger and smaller tolerances [from standard dimensions] should be laid on the sides of the oven and the machine, respectively.

No 40. In laying the vertical flue dividing wall bricks of the half oven (pan-lu) connecting flue in the center of the coke oven, special attention should be paid to the solid filling of the brick joints. The laying of the center dividing wall bricks should be alternated with that of the special shapes on the two sides and should not be done afterwards.

Note: Bricks of larger tolerances [believe to mean bricks larger than standard dimensions] should be selected in the laying of this center dividing wall.

No 41. In laying the furnace head ("lu-t'ou") of the combustion chamber, the bricks should be carefully processed to guarantee that the brick joints will fit tightly.

No 42. The laying of the vertical flue should start from the head of the oven and "ya-hsien" bricks should be placed inside the wall.

No 43. After five or six layers of the vertical flue have been laid, the bottom part should be cleaned and "t'iao-chieh [literally regulating] bricks should be placed. Moreover, steps should be taken to prevent the coal gas, air and waste-gas openings from being clogged up or damaged.

No 44. Before the covering layer of bricks of the vertical flue is laid, loose mortar and debris inside the vertical flue should be thoroughly cleaned out.

No 45. In laying the covering "t'ui-t'ai" layer of bricks of the vertical flue, attention should be paid to the firmness of the bricks and the squeezed out mortar should be cleaned away immediately.

No 46. Large bricks should be used for the cover of the carbonization chamber. This cover may also be in the form of an arch.

Note: When large bricks are used, expansion joints should be left on the sides of the bricks.

The suggested dimensions of the large bricks are 410 x 140 x 113 millimeters.

No 47. In laying the observation hole on the top of the oven, attention should be paid to the "verticality" of the hole.

No 48. Water should not be poured onto the red bricks used for the laying of the oven roof.

No 49. Drying oven openings should be left on the side of the wall on the upper part of the vertical flue. The shape of these openings should make it easy for them to be plugged with wedge shaped plugging bricks of similar dimensions.

No 50. The drying bed of the drying oven should be laid dry with clay bricks.

No 51. The Checkerwork bricks of the heat storage chamber are laid dry [without mortar]. Expansion joints should be left between the checkerwork bricks and the walls, and these joints are not filled with any material.

APPENDIX

1. Physical and chemical properties and particle size composition of low temperature silica fire clay.

1) Physical and chemical properties:

Table 3. Physical and Chemical Properties of Low Temperature Silica Fire Clay

Low Temperature Silica Fire Clay	
Chemical composition (on the basis of asked material)	
SiO_2	not less than 85%
Al_2O_3	not more than 8%
Degree of fire resistance	not lower than 1,580°C

2) Particle size composition:

Residue on one-millimeter sieve, not more than three percent; material passing through a sieve with 900 openings per square centimeter, not more than 90 and not less than 60 percent.

Note: if a sieve with 900 openings per square centimeter is not available, testing may be made on the following basis: residue on one millimeter sieve, not more than three percent; material passing through 0.5 millimeter sieve, not less than 90 percent.

2. Physical and chemical properties and particle size composition of ordinary fire clay.

1) Physical and chemical properties:

Table 4. Physical and Chemical Properties of Ordinary Fire Clay

Class	Degree of fire resistance (°C)	Content of Prepared Material (%)	Content of Crude Refractory Clay (%)	Moisture Content (%)
Class I	not lower than 1,710	70	30	not more than 8
Class II	not lower than 1,650	60	40	not more than 8
Class III	not lower than 1,580	50	50	not more than 8

2) Particle size composition:

Table 5. Particle Size Composition of Ordinary Fire Clay

Sieve Opening Size (mm)	Fine Particle	Medium Particle	Coarse Particle
0.5	55%	45%	35%
1.0	97%	--	--
2.0	100%	97%	--
2.8	--	100%	97%
4.0	--	--	100%

TECHNICAL SPECIFICATIONS FOR BRICKLAYING AND CONSTRUCTION OF 6.5-55 CUBIC METER BLAST FURNACES (DRAFT)

[This is a full translation of an article submitted by the Capital Construction Department, Ministry of Metallurgical Industry, appearing in Yeh-chin Chien-she (Metallurgical Construction), No 12, Peiping, 21 April 1959, pages 12-18.]

Chapter I. General Specifications

No 1. These technical specifications apply to the bricklaying and construction of 6.5-55 cubic meter blast furnaces and their hot-air furnaces [air preheating furnace].

No 2. During the bricklaying and construction of blast furnaces and hot-air furnaces, the environmental working temperature should not be below +5°C, and a temperature above zero should be maintained for the various types of materials during the work of bricklaying and construction.

No 3. In the laying of refractory bricks and large refractory concrete blocks, the joints should be completely filled with mortar, and they should be staggered.

No 4. When natural refractory materials (such as "pai-sha-shih" [literally, white sandstone], etc.) with the same characteristics as refractory materials are available, they may be used in place of the clay bricks of the furnace body and the hot-air furnace.

No 5. Bricklaying and construction should be carried out according to the design.

No 6. When the construction of two sections is carried out at the same time, necessary safety measures should be taken.

No 7. The degree of fire resistance and chemical composition of mortar should be compartible with the bricks used.

No 8. The checking of brick joint spacings should be made with a thickness gauge having the same thickness as the required brick joint spacing. The specification is considered to have been met when the depth extended by the thickness gauge is not more than 20 millimeters.

No 9. The physical and chemical properties of refractory materials should meet current refractory material standards issued by the Ministry of Metallurgical Industry.

No 10. During storage, refractory bricks and fire clay should be protected from moisture. Refractory bricks which have become wet should be dried before being used in construction.

No 11. Care should be taken in the transportation and storage of refractory products to prevent chipping and breaking.

No 12. With regard to materials to be used in the different positions, Table 1 should be followed.

Table 1. Materials Used in Different Positions

Item No	Bricklaying Position	Class & Grade, Refractory Brick Used	Composition of Mortor (%)	
1	Base, hearth	Class I, 1st grade blast furnace brick	Prepared clay Crude clay powder	65-70 30-35
2	Bosh, waist	Class I, 2nd grade blast furnace brick	Prepared clay Crude clay powder	60 40

Table continued--

3	Furnace body	Class II, 2nd grade blast furnace brick	Prepared clay 50 Crude clay powder 50
4	Hot air furnace arch roof	Class II, 1st grade hot air furnace brick	Prepared clay 50 Crude clay powder 50
5	Hot iar furnace wall	Class II, 2nd grade hot air furnace brick	Prepared clay 50 Crude clay powder 50
6	Hot air piping	Class II, 2nd grade hot air furnace brick	Prepared clay 50 Crude clay powder 50
7	Plastering of base	----------	Fire clay 70 Cement 30
8	Outer shell brick	Red brick	No 50 cement sand mortar or No 50 cement clay sand mortor
9	Space between clay brick and outer shell	----------	"shui-cha" or furnace ash
10	Space between clay brick and iron sheall	----------	Prepared clay 60 Cement 40

Consistency of Mortar	Particle Size of Mortar (mm)	Remarks
thin	Particle size 0.75	Or use a carbonaceous batter
thin	Particle size 0.75	Or use a carbonaceous batter

Table continued--

semithick	Particle size 1.5	------------
semithick	Particle size 1.5	------------
semithick	Particle size 1.5	------------
semithick	Particle size 1.5	------------
thick	________	------------
thick	________	Or use heat-resistant reinforced concrete
dry	Particle size 5-15	------------
thick	Particle size 2	________

Chapter II. The Laying of Refractory Bricks

Section 1. Blast Furnace Bricklaying

No 13. In the brick construction of the blast furnace, the method of parallel [simultaneous] laying of the red brick outer shell with the inner lining may be adopted.

No 14. The bricklaying operation is allowed to proceed only after the center position of the furnace shell has been determined and the iron notch, tuyeres, slag notch and large sets of structurals have been properly installed according to specifications.

No 15. The level and the diameter of the blast furnace brick layers should be checked after every five layers of bricks have been laid.

No 16. The brick joints on the outer surface of the red brick outer shell should be grooved.

1. Bricklaying of Furnace Base

No 17. Before bricks are laid [for the furnace base] the foundation must be leveled with a fire clay cement sand mortar according to the specified elevation of the bottom surface of the lowest layer of bricks of the furnace base.

No 18. The furnace base bricks must be selected according to their height and thickness. Only bricks of the same height are allowed to be used in the same layer, and bricks of the same thickness in the same row. [The term "thickness" here refers, evidently, to the width of the bricks.]

No 19. The parallel row bricklaying method should be adopted for the furnace base. The bricks of adjacent layers should be staggered. The parallel brick joints of the topmost layer of the furnace base should form a 30-45° angle with the center line of the iron notch.

No 20. The bricklaying of the furnace base should begin from the center line and the verticality of the first row must be strictly maintained.

No 21. The horizontal deviation of the brick surface of each layer of the furnace base should not be greater than five millimeters.

No 22. The bricks at the contact points between the furnace base and the iron sheet need not be carefully processed; the forming of natural joints is allowed. The joints are tamped solidly with the filler specified by the design.

No 23. The thickness of the brick joints of the furnace base cannot exceed one millimeter.

2. Bricklaying of Furnace Hearth

No 24. Before the laying of the hearth section, only that part of the topmost layer of the furnace base where the wall of the hearth is to be built needs to be smoothed level.

No 25. Bricks for the building of the furnace hearth section should be sorted out according to their thickness and only bricks of the same thickness may be laid in the same layer.

No 26. The laying of the furnace hearth section should proceed from the iron notch towards both directions.

No 27. The horizontal joints and the "fang-she-feng" [literally, radiation joint; possibly, referring to the vertical joints] of the hearth section may not exceed one millimeter in thickness.

No 28. The tolerance for the diameter of the furnace hearth may not be greater than 10 millimeters.

No 29. The horizontal tolerance of each brick layer of the hearth section should be maintained within five millimeters.

No 30. The brick structures within a diameter of 800 millimeters [meaning a radius of 400 millimeters] of the iron notch, the slag notch and the tuyeres should be constructed tightly against the iron shell. Where they are not tight against the iron shell, a mortar of similar properties as the bricks should be used to fill the spaces solidly.

No 31. The brick construction of the slag notch and the tuyeres should be carried out by taking the water cooling jacket into consideration or according to a pattern. A spacing of 10 millimeters should be left between the brick structure and the water jacket and this spacing should be filled solidly with a thick clay mortar.

No 32. The tolerance for the elevation of the center lines of the tuyeres, slag notch and iron notch should not be greater than five millimeters.

3. Bricklaying of Furnace Bosh

No 33. The bricks of the bosh should be laid tightly against the outer shell. The brick surfaces in contact with the outer shell need not be processed; natural joints are permitted. However, the joints are filled with a thick mortar.

No 34. The level of the brick layers of the bosh section should be strictly maintained. The topmost layer of bricks should be checked with a level and a guide ruler. If the surface level of the surrounding wall exceeds the permissible tolerance, the brick surface should be chipped or smoothed off and made level.

No 35. The diameter of the bosh should be maintained within a tolerance range of 10 millimeters.

No 36. The brick joints of the bosh should be 1.5 millimeters in thickness.

4. Bricklaying of Furnace Waist

No 37. The horizontal joints and the "fang-she-feng" of the brick layers of the furnace waist should not be greater than 1.5 millimeters.

No 38. The horizontal tolerance of the layers of bricks of the furnace waist should not be greater than five millimeters.

No 39. A spacing of 80-100 millimeters should be left between the furnace waist and the outer shell and this spacing should be filled with "shui-cha" or furnace ash as construction progresses.

No 40. The diameter tolerance of the furnace waist structure is 10 millimeters.

5. Bricklaying of Furnace Body

No 41. For the construction of the brick structure of the furnace body, the center line should be followed or a templet having the same incline as the furnace body should be used. Its radius tolerance is not permitted to exceed seven millimeters.

No 42. The deviation of the furnace body from the center must not exceed two thousandths of its height.

No 43. A space of 80-100 millimeters should be left between the inner lining of the furnace body and the outer shell. The space should be filled with either slag or "shui-cha" and the fullness of the filling must be guaranteed.

No 44. For every 12 layers of the inner lining clay brick of the furnace body, a layer of protruding brick support should be laid. A space of 10-20 millimeters should be left between the brick support and the outer shell.

No 45. Pieces of brick and debris should not be allowed to drop into the space between the clay brick and the outer shell.

No 46. The joints of the furnace body clay bricks should not be greater than two millimeters in thickness; the joints of the red bricks are eight millimeters.

No 47. The horizontal tolerance of the furnace body brick layers should be maintained within five millimeters.

No 48. Open spaces for the installation of structural elements should be left in the furnace body, red brick outer shell according to the design. When structurals are installed in these spaces, they should carefully tamped and constructed.

6. Bricklaying of Furnace Throat

No 49. The joints of the furnace throat clay bricks should not be greater than two milimeters; the joints of the red bricks are eight millimeters.

No 50. The spaces between furnace roof structural elements and the surface of the brick structure should be filled with a thick cement mortar.

No 51. The deviation of the center line of the furnace throat from the designed center line is not allowed to exceed 30 millimeters.

Section 2. The Bricklaying of the Hot Air Furnace and the Hot Air Piping

No 52. The bottom of the hot air furnace should be constructed before the installation of the hot air pipings inside the furnace. The laying of the furnace wall may begin after the installation of hot air pipings and frameworks inside the furnace.

No 53. The position of the combustion opening and those of the air distribution openings on the fire baffle wall should adhere strictly to the designed positions.

No 54. A space of 30 millimeters should be left between the clay bricks and the red bricks. This space is filled with slag or "shui-cha." The dropping of mortar and pieces of brick during the bricklaying operation is to be avoided.

No 55. The joints of the furnace wall clay bricks should not exceed three millimeters in thickness; those of the furnace roof clay bricks should not exceed two millimeters; and those of red bricks are to be eight millimeters.

No 56. In laying the furnace wall, the construction method of first laying the clay bricks and then the red bricks should be adopted.

No 57. The bricks at the touching surfaces between the furnace wall and the cold-and hot-air pipings should be carefully processed. The spaces should be completely filled with mortar.

No 58. The bricklaying work of the furnace roof may only proceed after screws of the framework have been tightened and after the structural beams at the foot of the furnace-roof arch have been properly installed.

No 59. The joints at the four corners of the furnace wall should be staggered. A space of 10-15 millimeters should be left between the contacts of the end walls within a radius distance along the furnace roof and the clay bricks of the furnace roof, and this space should be filled completely with a thick clay mortar [sic].

No 60. The brick joints of the hot-air pipings should not exceed two millimeters in thickness. No expansion joint needs to be left within the brick structure.

No 61. During the laying of the hot-air pipings, a suitable number of material-feeding openings may be cut on the piping. These openings are carefully closed and welded solidly after the work is completed to guarantee a close fit between the brick structure and the outer shell.

No 62. The circular laying of the hot-air pipings is allowed. However, the brick joints in the longitudinal direction must be staggered.

No 63. Openings for measuring gauges should be left on the hot-air pipings according to the design.

Chapter III. Carbonaceous Batter

Section I. Materials

No 64. The carbonaceous batter may be prepared from such materials as coke, anthracite coal, coal tar and anthracene oil.

Note: Technical requirements of the materials:

Coke:

Appearance: should be dense and show a silverish grey color, and not a black color due to insufficient firing;

Ash content: not more than 10%;

Volatile matter: 1%;

Fixed carbon: 85-92%.

Anthracite coal:

Ash content: not more than 10%;

Volatile matter: 1%;

Medium coal tar:

Softening point: 65-75°C.

Soft coal tar:

Softening point: 40-60°C.

Coal tar oil:

Specific gravity: not less than 1.15.

Anthracene oil:

Specific gravity: 1.1-1.12;

Moisture content: 1.5%

Distillation fraction: 210°C 10%; 230°C 25% 360°C 60%.

No 65. The materials used for the preparation of carbonaceous batters should be completely dried and dewatered. The dewatering temperature of coal tar should be preferably not over 140°C, and that of tar oil and anthracene oil not over 120°C.

No 66. For the preparation of a carbonaceous batter, a coal tar with a softening point of 40-60°C is preferred. However, a high softening point coal tar mixed with anthracene oil or tar oil to form a low softening point coal tar may also be used.

No 67. With regard to the powdered material for the preparation of the carbonaceous batter, powdered coke with a maximum particle size of four millimeters or anthracite coal with a maximum particle size of eight millimeters is allowed. For the powdered material, a maximum of 30 percent of the large particle anthracite coal may be added to the powdered coke. The particle size compositions of the powdered materials is shown in Table 2.

Table 2. Particle Size Composition of Powdered Materials

Size of Sieve Opening (mm)	4-8	1-4	0.075-1	smaller than 0.075
Powdered coke	--	40%	32%	28%
Anthracite coal and powdered coke	30%	20%	35%	15%

Note: 1. In the powdered coke, the portion smaller than 0.075 millimeters should not be less than 28 percent.

2. In the mixed powder, the portion smaller than 0.075 millimeters should not be less than 15 percent.

No 68. The ratio of preparation of a carbonaceous batter should be determined by laboratory experiment. The general range is as follows (weight basis):

Powdered filler, 80-84%; binder, 20-16%.

Note: When the tamping tool for construction is of poor quality, a low-softening point tar should be used.

No 69. To check the quality of a carbonaceous batter, the prepared batter is formed into a test piece under a pressure of 100 kg/cm^2 and a temperature of 80-100°C. The test piece should have the following physical properties after being calcined at 800-1,000°C in the absence of air:

Compressive strength: not less than 150 kg/cm^2.
Density: not less than 1.3.

If the laboratory is not equipped to carry out the above test, the quality of the batter may be tested by determining only the density of the test piece without calcination. The values or the density are specified as follows:

When the test piece is tamped solid with a pneumatic tool, its density should not be less than 1,220 kg/m^3.

Section 2. Construction

No 70. The carbonaceous batter may be prepared either on a weight ratio basis or on a volume ratio basis, but the accuracy must be within one percent. In the process of mixing the carbonaceous batter its transportation and application, special care should be exercised not to let any impurities such as dust and moisture enter the batter. The training of the construction personnel [to pay attention to] quality should be strengthened. Nonconstruction personnel should not be allowed to enter the construction site at will. During construction, attention must also be paid to labor protection and to fire prevention measures.

No 71. In the preparation of the carbonaceous batter, the powdered filler and the tar binder may be heated and mixed on an iron plate. The temperature of the carbonaceous batter during mixing should not be higher than 160°C. It must be mixed homogeneously before it is allowed to be transported to the working site to be used.

No 72. Before construction, the tamping equipment and tools must be carefully examined, and attention should be paid to their cleanliness.

The templet used should be strong and its surface should be planed smooth. There should not be any cracks. and holes in the templet.

No 73. The foundation layer of the furnace base should be swept clean before construction may begin.

No 74. The foundation layer of the furnace base should be coated with a thin layer of tar first. To raise the temperature of the foundation layer, the temperature of the first layer of carbonaceous batter may be increased to 180°C.

No 75. Pneumatic tools should be used to tamp the carbonaceous batter solid. Manual methods of tamping may also be employed, but care must be taken to tamp the batter as solidly as possible. The work of applying the carbonaceous batter should be continuous and should not be intermittent.

No 76. The application of the carbonaceous batter should be carried out in layers, each layer being 60-100 millimeters thick. Vigorous tamping should begin when the temperature of the carbonaceous batter falls below 120°C.

No 77. To carry out the tamping work, the tamping tool should be heated to a dark red. The surfaces of two layers of carbonaceous batter should be joined at an angle. When the first layer of carbonaceous batter has been solidly tamped, it should have a rough surface. Its quality should be checked, and when found to meet specifications the second layer may be applied.

No 78. When tamping reaches the iron notch, slag notch and tuyeres, special care should be taken to make sure that the batter is solidly tamped. Furthermore, the quality of the protective layer must also be assured. This is to prevent any damage after production has begun, as a result of oxidation of the carbon.

No 79. The templet may be taken down when tamping is finished, and only after the batter has cooled and its quality examined and found to meet specifications. Finally,

a protective layer not less than half a brick [in thickness] is built on the inner surface. A dry, refractory clay powder of 10-20 millimeters thick is filled in the space between the protective layer and the carbonaceous batter.

Chapter IV. Heat Resistant Reinforced Concrete and Heat Resistant Concrete

Section 1. General Specifications

No 80. For blast furnaces below 55 cubic meters in volume, heat resistant, reinforced concrete structures may be used in such sections as the outer shell of the furnace body, the supporting column of the blast furnace, the dust eliminator and the roof of the tubular hot air furnace. Heat resistant concrete structures may be used for the inside lining sections of the blast furnace body, the angles of the air-delivery piping and the tubular hot-air furnace.

No 81. Special calculations should be made of the combined influence of temperature and loading stresses on the heat resistant, reinforced concrete and heat resistant concrete structures.

No 82. The composition of heat resistant concrete is determined from the design. The properties and permissible working temperatures of the heat resistant concrete are given in Table 3.

No 83. For heat resistant structures which either hold very large loads or are subjected to severe impact and abrasive action, the standard grade of heat resistant concrete made from cement must not be lower than 200 and that made from waterglass not lower than 150.

No 84. For the steel of principal stress in the heat resistant, reinforced concrete structure, the use of t_5 deformed steel is most suitable. For the other framework steel and steel bands, t_0 or t_3 round steel may be used. The use of cold processed steel (cold stressed,

cold drawn and cold rolled) as the steel tendon (chin) of principal stress in heat resistant structures is not permitted.

No 85. With regard to the maximum working temperature of the steel tendon, it should not exceed 350°C on the low temperature side and 550°C on the high temperature side of the structure. To prevent the steel tendon from being subjected to too high a temperature, the position of the steel tendon should be on the side of lower temperature as much as possible.

No 86. The heat resistant reinforced concrete for the blast furnace body part of the outer shell should not be less than 150 millimeters in thickness. The steel ratio of the [circular direction] steel of principal stress is 0.5-0.8 percent and that of the vertical direction steel tendon is 0.3-0.6 percent. The thickness of the steel tendon protective layer should not be less than 30 millimeters in thickness. The materials used in the preparation of the heat-resistant concrete should be selected on the basis of the strength of No 200 and a temperature of 1,000°C.

Table 3. Properties of Heat-Resistant Concrete

Item No	Maximum working temp. (°C)	Concrete Materials		Concrete Standard No	Strength under maximum temp. (kg/cm^2)	Remarks
		Fine-ground part	Skeleton (ku-liao) part			
Heat-resistant Concrete Prepared from Alumina Cement						
1	1,400	none	chromite and chromium & magnesium type of prepared material	150-300	50-100	------

Table continued--

2	1,300	none	prepared clay material of not less than 1,730°C in degree of fire resistance	100-300	35-100	-----
		Heat Resistant-Conrete Prepared from Silicate Cement				
3	1,200	prepared clay material of not less than 1,730°C in degree of fire resistance	prepared clay material of not less than 1,730°C in degree of fire resistance	100-300	35-100	use under acid corrosive environment not permitted
4	1,150	prepared clay material and "white sandstone" of not less than 1,650°C in degree of fire resistance	prepared clay material of "hsieh-ts'u-shih," "white sandstone" and "chiao-pao-shih" of not lower than 1,650°C in degree of fire resistance	100-300	35-100	Same as above

Table continued--

5	1,100	prepared clay material and quartz sand of not lower than 1,580°C in degree of fire resistance	prepared clay of not lower than 1,580°C in degree of fire resistance	100-300	35-100	use under acid corrosive environment not permitted
6	1,000	powdered coal ash	-do-	100-300	35-100	-do-
7	700	pumice stone, clay product pieces, powdered coal ash and blast furnace "shui-cha"	basalt, diabase and "anshan-yen"	150-300	100-200	-do-
8	700	-do-	blast furnace slag	100-200	70-140	
9	700	-do-	tuff and clay product pieces	100	70	-do-

Table continued--

Heat-Resistant Concrete Prepared from Slag Silicate Cement

12	700	see Note 2	basalt, diabase and "an-shan-yen"	150-300	100-200	use under acid corro-sive environ-ment not per-mitted
13	700	-do-	blast furnace slag	100-200	70-140	
14	700	-do-	tuff and clay pro-duct pieces	100	70	

Heat-Resistant Concrete Prepared from Water Glass Containing Sodium Fluorosilicate

15	1,200	magnesite brick pieces and metal-lurgical magnesite	magnesite brick, chrome-magnesium brick pieces & metallur-gical magnesite	150-200	50% of original strength at 800°C	suitable for use in the presence of NaCl, Na_2CO_3, Na_2SO_4, NaF & re-generated alkali solution
16	1,000	chrome-magne-sium mineral	chromite	100-200	90-180	same as above & places under acid action (except HF)

Table continued--

17	1,000	prepared clay material of not lower than 1,730°C in degree of fire resistance	prepared clay material of not lower than 1,730°C in degree of fire resistance	100-200	90-180	same as above
18	900	prepared clay material, quartz sand and "an-shan-yen"	semiacid refractory material or prepared clay of not lower than 1,580°C in degree of fire resistance	100-200	90-180	same as above

Note: 1. Clay product pieces under item 7 refer to broken pieces of red bricks, tiles and waste materials from the ceramic and pottery industry.

2. Fine ground materials should be added when the amount of slag in the slag silicate cement is less than 90 percent.

No 87. The heat resistant, concrete inner lining of the furnace body may be laid with concrete blocks; ones of around 30 kilograms would be suitable. The heat-resis-

tant concrete for the making of blocks maybe selected on the basis of a maximum working temperature of 1,200°C.

No 88. For the furnace body of a 55 cubic meter blast furnace, the thickness of the concrete blocks should not be less than 575 millimeters; for a blast furnace of less than 28 cubic meters, the thickness should not be less than 345 millimeters. A space of 80-100 millimeters should be left between the outer shell and the inner lining and this space is filled with such heat insulating material as "shui-cha" or slag cotton. At one meter intervals along the height of the inner lining, a ring of supporting layer should be built to hold up the heat insulating material.

No 89. To facilitate inspection, repairs and observation, a manhole of approximately 500 x 700 millimeters should be left on the lower part of the furnace body outer shell.

No 90. The construction of the furnace body outer shell as a single body is preferred.

No 91. "Tao-lei-shih" [literally, inverted rib type] of heat resistant, reinforced concrete plates are used for the roof of the hot-air furnace. The working temperature of the heat-resistant concrete is 1,200°C and its strength is No 150. Three steel tendons in the rib are principal tensile stress steel tendons. Prefabricated plates are preferred.

No 92. A heat resistant reinforced concrete with a working temperature of 700°C may be used for the outer shell of the dust eliminator. Its thickness should not be less than 150 millimeters. The steel tendon ratio for the principal stress circular tendon is 0.4-0.6 percent and that of the vertical direction steel tendon is 0.3-0.5 percent. The strength of the heat-resistant concrete should not be below No 150. The protective layer thickness for the steel tendon should not be less than 30 millimeters. For the skeleton part of the material, pieces of red brick or a blast furnace slag of better stability, etc., may be used.

Section 2. Materials

No 93. For the binding material of the heat-resistant concrete, alumina cement, silicate cement, and slag silicate cement and water-glass with not less than 50 percent of "shui-cha" added may be used.

Note: Volcanic ash silicate cement using diatomaceous earth, pumice tuff or waste aluminum sulfate as water hardening material is not permitted in the preparation of heat-resistant concrete.

No 94. The standard of cement must not be below No 300.

No 95. The modulus of waterglass should not be below 2.6, but it should not be higher than 3.2 either. A modulus between 2.6-3.2 should be used.

No 96. For the fineness of the various types of fineground materials used (quartz and powdered coal ash excepted), it should be guaranteed that not less than 70 percent of the material pass through a No.0085 screen (4,900 openings per square centimeter).

No 97. Quartz sand used as fine ground material should contain not less than 90 percent silica. For the fineness of this material, it should be guaranteed that not less than 85 percent of it pass through a No. 0085 screen. However, the amount of the material passing through a No. 0150 screen (1,600 openings per square centimeter) should be 100 percent.

No 98. The fineness of powdered coal ash used as a fine-ground material should meet the requirements specified under item number 97. And it should contain not less than 25 percent of Al_2O_3 and not more than four percent of sulfate and loss from heating should not exceed eight percent.

No 99. The particle size of coarse skeletion materials used in large and thick structures should not exceed 40 millimeters, but in other structures it should not exceed 20 millimeters.

No 100. The grading of fine skeleton materials should follow the requirements of Table 4.

Table 4. Grading of Fine Skeleton Material

Sieve opening size (clear diameter, millimeters)	5.0	1.2	0.3	0.15
Fraction of material going through sieve (%, weight basis)	85-100	45-80	5-30	0-25

No 101. Chromite should contain not less than 35 percent chromic oxide (Cr_2O_3), not more than nine percent silicon oxide (SiO_2), not more than two percent calcium oxide, and it should not contain any harmful impurities.

No 102. Refractory clay brick pieces and broken pieces of semi-acid products used as coarse and fine skeleton materials in the manufacture of heat-resistant concrete should meet the following requirements:

1. The degree of fire resistance should meet the figures listed under Table 3.

2. The limit of compressive strength should not be lower than 100 kilograms per square centimeter.

3. They should not contain any slagged and vitrified particles.

4. Used acidified refractory clay products containing more than 0.3 percent sulfate should not be used.

No 103. The limit of compressive strength of broken pieces of red bricks (green bricks) should not be smaller than 100 kilograms per square centimeter. Dirt and mortar on used bricks should be cleaned off.

No 104. Water used in the mixing of ordinary concrete may be used in the mixing of heat-resistant concrete.

Section 3. Construction

No 105. Rust on the steel should be cleaned off before using. Electric welding or iron wire may be employed in joining and stabilizing the steel tendons. The requirement of contact connection is the same as in ordinary reinforced concrete.

No 106. Before pouring the concrete, the templet should be carefully examined as to its design requirements and its firm anchorage.

No 107. The heat-resistant concrete may be either mechanically or manually mixed. The addition of materials should be carried out on a weight basis. The accuracy of the cement, fine ground material, and water weights should be within two percent and that of fine and coarse skeleton materials should be within five percent.

No 108. Before mixing, the mixing pipe, bucket (or jar) and iron plate should be carefully cleaned of any dirt, impurities and remaining pieces of ordinary concrete.

No 109. The process of mixing the heat-resistant concrete is the same as mixing ordinary concrete. The various materials should be mixed thoroughly in their dry state and then water added. When waterglass is used in the preparation of the heat-resistant concrete, only two thirds of its total quantity is first added. The mixture of fine ground material and sodium fluorosilicate is then added and this is followed by fine and coarse skeleton materials. After mixing for 2-3 minutes, the remaining one third of waterglass is then added and mixing is continued immediately.

No 110. The fluidity of the heat-resistant concrete should be determined by the method of tamping. When the vibration method is employed, its "tan-lo-tu"

[literally, degree of crumbling] should not be greater than 20 millimeters; when manual tamping methods are employed, it may be 30-50 millimeters.

No 111. The heat-resistant concrete should be poured in layers and the thickness of each layer should not exceed 250 millimeters. When manual tamping is permitted, its thickness should not be greater than 150 millimeters.

No 112. When construction with heat-resistant concrete having a cement binding material is carried out above +7°C, no special curing method needs to be employed. However, when construction is carried out below 7°C, winter construction methods should be used.

No 113. When heating a heat-resistant concrete prepared with alumina cement, the temperature should not be above +25°C; when heating a heat-resistant concrete prepared with silicate cement, the temperature should not exceed +40°C.

No 114. When pouring heat-resistant concrete which has been prepared with waterglass, a temperature of not lower than +15°C should be guaranteed.

No 115. The addition of calcium chloride is not permitted during the winter construction of heat-resistant concrete. The heating of heat-resistant concrete which has been prepared with cement may be done electrically or by steam. Only dry heating is allowed for heat-resistant concrete which has been prepared with waterglass (electrical heating, superheated steam heating or steam heating in a closed pipe), and a good air circulation should be maintained to allow steam evaporation.

Section 4. Curing and Dismantling of Templet

No 116. For heat-resistant concrete prepared with a cement binding material and construction under normal temperatures, water curing should begin 24 hours after pouring. For heat-resistant concrete prepared with

Table 5. General Rules of Drying and Heating with Heating Equipment

Technical Conditions	Unit	Thickness of Structural Part (centimeter)			Remarks
		below 20	20-40	over 40	
Rate of heating up to 100-150°C	°C/hr	20-40	10-20	5-10	----
Minimum maintained time, 100-150°C	day-night	0.33	3	7	----
Rate of heating, 100-150°C to 600°C	°C/hr	100-200	50-100	25-50	----
Rate of heating, 600°C to working temperature	°C/hr	not specified	250	100	----

silicate cement the process should be delayed for six days, and for heat-resistant concrete prepared with alumina cement it should be delayed for two days.

No 117. For heat-resistant concrete prepared with waterglass the pouring of water on the concrete during hardening is forbidden.

No 118. The time of templet dismantling of heat-resistant reinforced concrete and heat-resistant concrete must follow the following rules:

1. Templets of ordinary structures: those for concrete prepared with alumina cement should wait for one day and night; those for concrete prepared with silicate cement should wait for five days and nights; and

those for concrete prepared with waterglass should wait for three days and nights.

2. Templets of more important structures: those for concrete prepared with alumina cement should wait for two days and nights; those for concrete prepared with silicate cement should wait for seven days and nights; and those for concrete prepared with waterglass should wait for three days and nights.

Section 5. Drying and Heating

No 119. For heat-resistant concrete prepared with cement binding materials, drying is carried out after the designed strength has been attained. For heat-resistant concrete prepared with waterglass, drying may proceed immediately after the dismantling of the templet.

No 120. Drying with heating equipment should proceed according to Table 5.

TECHNICAL SPECIFICATIONS FOR THE CONSTRUCTION OF SMALL CONVERTER LINING (DRAFT)

[This is a full translation of an article submitted by the Capital Construction Department, Ministry of Metallurgical Industry, appearing in Yeh-chin Chien-she (Metallurgical Construction), No 12, Peiping, 21 April 1959, pages 18-19.]

No 1. These technical specifications apply only to small converters which use sintered dolomite batter as their inner linings.

No 2. The batter should be prepared with a binder and a filler.

Coal tar or a mixture of coal tar and tar oil (chiao-yu) may be used as binding materials, and sintered dolomite is used as the filler.

No 3. The use of aqueous type of binder in the batter is forbidden.

No 4. The composition of the batter on a weight basis is: filler 100: binder 7 - 10.

Note: Less than 70 percent of recovered dolomite may be used in the filler. The use of recovered dolomite is especially suitable for fillers whose grain size requirement is below one millimeter.

No 5. The particle grading of the filler is generally (weight ratio %):

Particle size 4-10 millimeters	30
Particle size 1-4 millimeters	20-30
Particle size below 1 millimeter	40-50

No 6. Dolomite calcined at above 1,500°C should be used as the filler; the use of a greyish white, loose and lightly burned dolomite is not allowed.

No 7. The chemical composition of the unburnt or crude dolomite should be: MgO not less than 17 percent; SiO_2 not more than two percent, and R_2O_3 not more than two percent. The chemical composition of the sintered dolomite should be: MgO not less than 28 percent, SiO_2 not more than seven percent, R_2O_3 not more than seven percent, and the loss of weight upon sintering should be less than one percent.

No 8. The use of sintered dolomite hydrolyzed as a result of dampness is forbidden.

No 9. Both sintered dolomite and recovered dolomite material should be kept in a dry place. The time of their storage should not exceed five days, while the time of storage of powdered material should not exceed two days. The material should not be mixed with such impurities as fluorite, sand or earth.

No 10. In preparing the dolomite batter, a coal tar with a softening point of 45-60°C is preferred. A low softening point coal produced by mixing a high softening point tar with anthracene oil or tar oil may also be used.

No 11. Petroleum tar should not be used as binder.

No 12. The binder should be heat-processed and its water content must be below 0.5 percent.

No 13. Before mixing, large, medium, and small particle size fillers should be separately heated on an iron plate to 160-180°C. The binder should be dried by heating at a temperature of 150-180°C before it can be used.

No 14. During the process of mixing, the large and medium particle size fillers should be soaked first in the binder for at least five minutes before the small particle size filler is added and homogeneously mixed. The temperature during mixing should be maintained at around 140°C.

Note: The mixed material should not show white spots or the presence of oil particles.

No 15. Before the plastering of the converter lining, the plastering hammer used should be preheated. The plastering process must be carried out continously and evenly with every full blow followed by a half blow. The mixing and the plastering should be done simultaneously and closely coordinated. The method of thin layers and repeated plastering should be adopted for the tuyere section.

No 16. The plastering should be carried out in layers. Each layer of material is 60-80 millimeters thick. During the process of plastering, the temperature of the material must be above 100°C and the surface temperature of the material layer should preferably be above 80°C after the layer has been plastered on.

No 17. The degree or density of compactness of each layer of plastered batter may be examined by a five-millimeter diameter flat head steel rod; when the steel rod is forced against the plastered batter with the hand, it should not enter into the compacted batter.

No 18. When the plastering work progresses to the air pipe section, the angle of the air pipes should be guaranteed at less than 6-8 degrees.

No 19. In drying the converter lining, air should be pumped in immediately and continuously after the fire is lighted to raise the temperature rapidly. The air pressure should be gradually increased from low to high. The drying temperature should generally reach above 1,400°C. The drying time is approximately 6-12 hours.

Note: During drying, the tuyeres should be heated more than the other parts.

No 20. It is suggested that the shape of the converter hearth follow that of the diagram shown below. The rectangular shape is selected for the tuyere section.

No 21. During production, maintenance should be strengthened. Overblowing and underblowing should be avoided. Moreover, the consumption of silicon-iron and fluorite should be reduced in order to prolong the life of the converter lining.

1524 END